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<p>(54) Title: DIGITAL VIDEO APPARATUS USER INTERFACE</p> <p>(57) Abstract</p> <p>A method and apparatus for processing information stored on a storage medium, such as a digital video disk (21), involves accessing information stored on the medium and determining whether information stored on the storage medium includes unrated program information. If so, a user (31) is given the opportunity to override a control condition of the system that prevents playback of unrated program information. If override is selected, playback of the unrated program information is enabled and, upon completion of playback, the control condition of the system may be restored to prevent playback of other unrated program information. Override may be conditioned upon the user first entering a password. The mode of operation that permits override of the control condition for preventing playback of unrated program information mode of operation may be selectively enabled.</p>			
<pre> graph TD     Start((Start)) --&gt; Wait[Wait for PLAY command]     Wait --&gt; Rating{does selected disc/title/portion have rating info?}     Rating -- Y --&gt; Play[Play disc/title/portion in accordance with the parental rating]     Rating -- N --&gt; OSD[Display OSD message and wait for user selection]     OSD --&gt; Override{override of unrated info mode enabled?}     Override -- Y --&gt; Password[Display password challenge]     Password --&gt; OverrideSel{Override selected?}     OverrideSel -- Y --&gt; Unlock[Unlock parental control]     Unlock --&gt; Play     Play --&gt; Return[Return to unrated disc/title/portion lock]     Return --&gt; Stop((Stop))     OverrideSel -- N --&gt; MaxAttempts{Max # of attempts entered?}     MaxAttempts -- N --&gt; Play     MaxAttempts -- Y --&gt; Unlock     Unlock --&gt; Play     Play --&gt; Return     Return --&gt; Stop </pre>			

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## DIGITAL VIDEO APPARATUS USER INTERFACE

The present invention relates to a user interface for a digital video apparatus, and in particular, a user interface for a digital video apparatus capable of 5 restricting playback of stored video and audio information in response to program related information, such as parental control ratings, included with the video and audio information.

Video signal processing systems that utilize storage media having 10 digitally compressed video and audio information recorded thereon can give the user a vast number of options for controlling playback of a video title stored on such a media. One such system that is gaining rapid popularity comprises a video disc player adapted to process information stored in accordance with the digital video disc (DVD) specification. The information on a DVD formatted disc is recorded as 15 discrete packets of data, in accordance with the applicable video and audio data compression standards, wherein designated packets carry data associated with various data streams, such as alternative video angles, audio tracks, subpicture streams, etc. A video disc player reading a DVD formatted disc may be controlled to 20 display certain packets of data and skip over others. A single disc may allow playback of multiple camera angles, story endings, scenes according to a ratings content, etc. Using this capability, the DVD system can be used to prevent 25 unauthorized access to information on a particular disc as well as seamlessly provide multiple variations of a video title in accordance with user commands.

One useful application of the restricted access and seamless branching 25 feature of the DVD system relates to parental control of material that can be played from a designated disc player. Typically, a DVD player allows the user to select a 30 parental control rating, usually varying from 1 to 8 wherein 1 is the least restrictive and 8 is the most restrictive. This user selected parental rating is used to establish a control condition of the system that automatically restricts the playback of discs, video titles on a disc, or scenes in a video title using that disc player based on the parental rating authored on the disc or video title. Such parental ratings generally correspond to the movie rating of the Motion Picture Association of America (MPAA).

During disc playback, the DVD player compares the user selected 35 parental rating against the parental rating assigned to the disc or video title and only allows playback of the disc, video title or certain scenes from the video title if the user

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selected parental rating equals or exceeds the parental rating of the disc or video title. In the case of multiple playback sequences, the DVD player follows the playback sequence having a parental rating that corresponds to the user selected parental rating.

5        Ordinarily, a user must call up and navigate through the disc player's set up menu to select or change the user selected parental rating. Once selected, the user selected parental rating applies to all the discs played back using that disc player.

10      However, the parental control feature described above is not effective when the disc, or a video title on the disc, or a portion of a program or information on a storage medium does not have a parental rating associated with it. In such a case, a disc player will usually playback the contents of the disc, or video title set, without any parental ratings restriction. However, under some circumstances a user may wish to restrict access to an unrated video disc, or certain video titles on the disc, or a 15     particular portion of a disc, for example personally recorded discs or video titles. The present invention recognizes that it is desirable to provide a user interface, method and apparatus which allows a user to apply a lockout feature with respect to an unrated disc or video title or portion of information stored on a storage medium to restrict access to the contents of the unrated information.

20      In accordance with the present invention, a user interface, method and apparatus is provided which permits a user to establish a system lock condition in a disc player with respect to unrated discs or video titles or portions of stored information thereby preventing that disc player from playing unrated discs or video titles or programs or portions of stored information. The system provides the user with an opportunity to dynamically override the system lock condition to unlock the 25     player so that the disc player can playback a selected unrated disc or video title or portion of stored information. In one mode of operation, the system automatically reestablishes the system lock condition relocking the player for unrated information after completing playback of the selected unrated disc, video title, or portion of the stored information. In another mode of operation, the player remains unlocked 30     following completion of playback of the unrated information.

The invention will be described with reference to the accompanying drawings, wherein:

Fig. 1 is a block diagram of a video processing system in accordance with the DVD specification;

Fig. 2 is a block diagram of a digital video disc player suitable for implementing the unrated disc lockout feature of the present invention;

5 Fig. 3 is a block diagram illustrating navigation between the disc player domain and the DVD domain;

Fig. 4 is a detailed block diagram illustrating navigation between the disc player domain and the DVD domain;

10 Fig. 5 is an example of an on screen information display that provides player and disc status information;

Fig. 6 is a diagram of a data structure in accordance with the DVD 15 format;

Fig. 7 is a block diagram of a presentation structure in accordance with the DVD format;

15 Figs. 8 a-b are block diagrams illustrating sample playback options available in the DVD format;

Fig. 9 is an on screen display suitable for overriding the unrated disc 20 lockout feature of the present invention;

Fig. 10 is a flowchart illustrating the steps for implementing the dynamic override of the unrated disc lockout feature of the present invention; and

Fig. 11 is a flowchart illustrating steps for implementing another embodiment of the dynamic override of the unrated disc lockout feature of the present invention.

25 Although the exemplary embodiment is described with reference to a digital video apparatus adapted to read compressed video and audio data from a disc and to process the data in accordance with the DVD specification, it is to be understood that the present invention may be used in any video processing apparatus capable of processing digital video and audio information, wherein program related information included with the video and audio information can be used to selectively restrict the playback of the video and audio information on the disc.

30 Also, it is to be understood the term "unrated disc lockout" refers to locking the disc player to prevent playback of unrated discs and/or unrated video titles.

Fig. 1 is a block diagram of video processing system 20 in accordance with the DVD specification. In particular, Fig. 1 illustrates the basic relationship between presentation data and navigation data in video processing system 20 comprising disc player 24 and DVD formatted disc 21. The contents of disc 21 are 5 read by disc player 24 and displayed on display 28 in accordance with commands from user control device 31. Disc 21 includes presentation data 22 and navigation data 23, wherein presentation data 22 comprises the data to be played back in the form of video, audio, subpictures, etc., and navigation data 23 comprises control data for determining how presentation data 22 is displayed. Disc 21 may also include data 10 to generate a menu for allowing the user to interactively control the manner in which presentation data 22 is displayed.

Disc player 24 includes presentation engine 25 and navigation manager 26, which may be implemented in microcontroller 40 described with respect to Fig. 2. Presentation engine 25 receives presentation data 22, and under control of 15 navigation manager 26, provides an output to display 28. Display 28 comprises audio output device 30 and video display 29. Navigation manager 26 includes user interface control 27 which provides a user interface, creates menus, etc. Navigation manager 26 uses information from navigation data 23 to control the output of presentation engine 25 to display 28. User control device 31 is coupled to navigation 20 manager 26 and allows for user entry of data to control the manner in which navigation manager 26 controls presentation engine 25.

Fig. 2 is a block diagram showing the basic elements of an exemplary digital video disc player suitable for use in system 20 of Fig. 1 and for implementing the unrated disc lockout feature of the present invention. The construction and 25 operation of these elements are known to one of ordinary skill in the art and will not be discussed in detail here. Disc player 24 comprises motor and pickup assembly 26 which, under the control of servo processor 29, spins the disc and reads the information stored thereon. Preamp 27 and DVD data processing unit 28 translate the electrical pulses from motor and pickup assembly 26 into digital data that can be 30 further processed by digital audio/video decoder unit 30. DVD data processing unit 28 typically performs functions such as demodulation, error correction and descrambling of the raw data read from the disc so that the data is in a suitable format for decoder unit 30.

Decoder unit 30 receives the demodulated, error corrected and descrambled data, processes the data, and provides the appropriate video and audio signals to a display unit, such as a television set. Decoder unit 30 comprises data stream demultiplexer 32 which demultiplexes the data from data processing unit 28 into a plurality of separate data streams, including a video stream, an audio stream and a subpicture stream, and provides the data streams to their respective data decoders. Video decoder 31 receives the video stream and provides a video signal to mixer 33. Subpicture decoder 34 receives the subpicture stream and provides data to on screen display (OSD) control 35 which provides OSD video signals to mixer 33. The combined video signal from mixer 33 is provided to NTSC/PAL encoder 42 which provides a video signal that conforms to the appropriate video signal standard to a video display device. Audio decoder 36 receives the audio streams from data stream demultiplexer 32 and provide the appropriate audio signals to an audio system.

Microcontroller 40 controls the operation of disc player 24.

Microcontroller 40 is coupled to user control device 31, which may comprise IR remote control devices, front panel buttons or the like, and translates data from user control device 31 to control the operation of the various elements of disc player 24 described above. Typically, microcontroller 40 is also configured to control various access features of disc player 24 including, but not limited to, parental lock out, decryption of encrypted discs, dialing remote controllers to gain access to encrypted discs. Microcontroller 40 may be embodied in various forms, including, but not limited to, a dedicated integrated circuit, or a part of a decoder/controller unit. Microcontroller 40 may be comprised of one of a plurality of suitable controller units, including, but not limited to STI 5500, manufactured by SGS Thomson.

Fig. 3 illustrates the basic navigation scheme between the video player domain 60 and the disc domain 62. Entering a PLAY command or calling for guide data moves control to disc domain 62, wherein title playback proceeds as indicated by title playback block 63 or a title menu is displayed as indicated by title menu block 64. On screen selections made from the title menu controls the playback sequence. A STOP command returns the user to player domain 60.

A more detailed illustration of the navigation scheme between player domain 60 and disc domain 62 is shown in Fig. 4. As shown in Fig. 4, player domain 60 includes player menu 61 for allowing the user to select certain operating

conditions for the player, for example parental control ratings. Also, DVD domain 62 includes title menu 64 for providing information about the respective video title. On screen selection from title menu 64 may transfer the user to title playback block 63 which includes provisions for root menu 65. Root menu 65 may be authored onto a disc to provide information about available options on the disc including, but not limited to, subtitles, audio tracks and camera angles.

If the disc does not include a root menu 65 authored thereon, it is advantageous to include a provision for generating an informational display, developed from the actual video and audio information stored on the disc, which identifies and displays the available options to the user. Such a provision is indicated by information displays block 66. Fig. 5 illustrates an example of an informational display 75 that may be used for identifying and displaying the options available on the disc to the user when a root menu 65 is not available from DVD domain 62. Alternatively, disc player 24 may be configured to allow the user to select information display 75 rather than root menu 65 even if root menu 65 exists in DVD domain 62.

As shown in Fig. 5, information display 75 comprises text display portion 76 surrounded by a plurality of displays and buttons 77-87 for providing information about the contents of the disc and allowing the user to make various selections to control various aspects of the disc playback. Timer display 77 provides time information regarding the disc being played and transport display 78 shows the direction and speed of the disc drive. Button 79 provides access to information regarding the number of the current title. Button 80 provides access to information regarding the number of the current chapter. Button 81 allows the user to change the playmode setting of disc player 24. Button 82 allows the user to access the root menu of the disc. Button 83 provides access to information regarding subtitles on the disc. Button 84 allows the user to select from available audio streams. Button 85 allows the user to select from available camera angles. Button 86 allows the user to select from available repeat modes. Button 87 allows the user to set bookmarks and jump to a previously set bookmark.

Fig. 6 illustrates a data structure in accordance with the DVD specification and suitable for use in video processing system 20. The data structure is hierarchical, wherein each data block is divided up into component data blocks, which are further divided into smaller component data blocks. At the top of the hierarchy is a video manager block and one or more video title sets. The video

manager includes a control data block having control information applicable to the disc and a disc menu. Each video title set corresponds to a designated program unit, for example, a movie or an episode of a television show.

Each video title set includes a control data block having control information applicable to the video title set, a title menu, followed by the title content, and a control data backup block. The title menu and the title content are each comprised of video object sets, wherein each video object set comprises a plurality of video objects. Each video object is comprised of a plurality of cells and each cell is in turn comprised of a plurality of video object units. Each video object unit is comprised of a navigation pack and a plurality of packs, which are subdivided into a plurality of packets. The smallest addressable block of data is a cell, wherein a cell may hold data for as short as a single scene or as long as an entire movie.

In implementing the parental control feature, a parental rating may be encoded in the video manager to control access to the entire disc or may be encoded in the control data block of each respective video title set to control access to a particular video title set. If the parental control is encoded in the video manager, disc player 24 only allows appropriate playback of the disc when the user selected parental rating equals or exceeds the parental rating encoded in the video manager block. If the parent rating is encoded in the control data block of the video title set, disc player checks the parental rating of each video title set prior to playback of that video title set. The relationship of the present invention with regard to the encoded parental ratings is discussed further below.

Fig. 7 illustrates a presentation structure in accordance with the DVD format and suitable for use in video processing system 20. The presentation structure is overlaid onto the data structure shown in Fig. 6. The presentation structure and the data structure intersect at the cell level. As shown in Fig. 7, each video title set may be comprised of a plurality of parental blocks 90, wherein each parental block is comprised of one or more program chains (PGCs) 92. Each program chain contains program chain information block 94 and video object set 96. Program chain information block 94 includes one or more programs (PGs) 96, each of which include a collection of pointers to cells 98 contained in respective video objects 100 in video object set 96. Programs 96 link cells 98 together and indicate the order in which they are to be played. Therefore, by providing the appropriate pointers to the desired cells, a program chain 92 provides a particular playback

sequence and a collection of program chains 92 provide a playback sequence for the video title set. It can be seen that multiple parental blocks, each containing different program chains, may be created to generate multiple playback sequences corresponding to different parental control ratings.

5        Different versions of a video title set, corresponding to different parental control ratings, may be provided by the disc author to enable disc player 24 to seamlessly branch between various scenes to provide multiple playback sequences for a particular video title set. By setting the user selected parental rating to a low level, objectionable scenes may be skipped over for younger viewers, while an  
10      unedited version of the program may be viewed by older viewers by setting the user selected parental rating to a higher level. The seamless branching is achieved by linking and displaying the desired cells, programs and program chains as desired.  
15      Figs. 8 a-b illustrate a single playback sequence and a multiple playback sequence provided by seamlessly branching between groups of program chains. In Fig. 8a, the disc only provides for a single playback sequence which comprises program chain #1, wherein the playback proceeds in one continuous sequence. In Fig. 8b, multiple playback sequences are provided, wherein a G-rated sequence would follow program chains 1, 2, 4 and 7, while a PG-rated playback sequence would follow program chains 1, 3, 5 and 8, and an R-rated playback sequence would follow program chains  
20      1, 3, 6 and 9.

As noted above, parental control can also be implemented by completely preventing access to a disc based on a parental rating encoded in the video manager or to a video title set based on a parental rating encoded in the control data block of a video title set. In that case, disc player 24 compares the user selected parental rating against the encoded parental rating and determines whether playback of the disc or video title set is permitted. If the user selected parental rating equals or exceeds the parental rating of the disc or video title set, disc player 24 proceeds to playback the selected disc or video title set. If the user selected parental rating is below the parental rating of the disc or video title set, disc player 24 prevents playback of that disc or video title set.

As noted above, the present invention recognizes the parental control feature described above does not apply when a disc or a video title set is unrated or does not have a parental rating associated with it. The present invention further recognizes that a user may wish to apply the parental control feature to unrated discs

or video title sets thereby preventing playback of such discs or video title sets. As such, disc player 24 provides a user with the option of locking disc player 24 with respect to unrated discs or video title sets. This option may be implemented in a number of ways, including, but not limited to, providing an option in the player set up 5 menu, in the parental control set up sub-menu, to lock disc player 24 for unrated discs and/or video title sets. The set up menu may be generated under the control of microcontroller 40 as known in the art. Preferably, this option would be selected in the same manner in which the user selects a particular parental rating for disc player 24. Once the unrated disc lockout feature is selected, the control system of disc 10 player 24 establishes a system control condition which automatically locks, or prevents playback, of all discs or video title sets which do not have a parental rating associated with it.

However, after the unrated disc lockout feature has been selected, the user may wish to dynamically override the lockout feature during playback of a 15 selected disc or video title set. In such a case the user may wish to avoid the inconvenience of having to stop the disc, call up and navigate through the player set up menu to disable the lockout feature, play the disc or video title set, and then reset the unrated disc lockout feature after playback is complete. Therefore, the present invention also allows the user to dynamically override the unrated disc lockout 20 feature, wherein disc player 24 automatically resets the unrated disc lockout feature after playback of the selected disc or video title set is complete.

A suitable on screen display for prompting user override of the unrated disc lockout feature is shown in Fig. 9. Display 110 indicates that the selected disc or video title set is an unrated disc or video title set and that the unrated disc lockout 25 feature must be overridden to play the selected disc or video title set. Display 110 asks the user to select button 112 to override the unrated disc lockout feature and to select button 114 to cancel the current selection. The selection and navigation between the two buttons may be performed using any conventionally known user interface methods, for example, using cursor control buttons and an ENTER key on a 30 remote control.

If the user selects button 112 to accept the override option, disc player 24 displays a password challenge. This password challenge may take many forms, including, but not limited to entering a numerical code selected by the user upon initial setup of disc player 24. If the user successfully passes the password

challenge, disc player 24 automatically overrides the unrated disc lockout feature and resumes playback of the selected disc or video title set. If the user selects the cancel selection button 114, disc player 24 stops the disc and waits for further commands. It is to be understood that the user interface described above may be implemented 5 using techniques known to one of ordinary skilled in the art, for example, programming microcontroller 40 to implement the various steps.

A flowchart illustrating the steps for implementing the dynamic override of the unrated disc lockout feature is shown in Fig. 10. In step 122, disc player 24 waits for the user to send a PLAY command and upon receiving the PLAY command 10 searches the disc or video title set for a parental rating associated with the disc or video title set. If disc player 24 determines in step 123 that the disc or video title set includes a parental rating, disc player 24 proceeds to playback the selected disc or video title set in accordance with the parental rating in step 124.

If disc player 24 determines in step 123 that the selected disc or video 15 title set does not include a parental rating, disc player 24 displays an on-screen display message, such as the one shown in Fig. 9, and waits user response. If disc player 24 determines in step 126 that the cancel selection option is selected, disc player 24 goes to step 127 and waits for further user commands.

If disc player determines in step 126 that the user has selected the 20 override option, disc player 24 issues a password challenge in step 128. If disc player 24 determines in step 129 that the password entered by the user is incorrect, disc player 24 determines in step 130 whether the maximum number of password attempts has been entered. If so, disc player 24 stops the disc and waits for further commands in step 127. If not, disc player 24 reissues the password challenge in 25 step 128 and waits for the user to enter another password. Alternatively, disc player 24 may allow the password attempt for a predetermined period of time or for some combination of time and number of attempts.

If the disc player determines in step 129 that the password is correct, disc player 24 overrides the unrated disc lockout feature and proceeds to playback 30 the disc or video title set in step 131. In step 133, the system resets the unrated information lockout feature upon completion of playback of the unrated information. In this way, a user can override the unrated disc lockout feature for a selected disc or video title set or portion of the stored information and reset the lockout feature after completing playback without having to call up and navigate through the player set up

menu. However, modifications of the arrangement in Fig. 10 are possible. Specifically, step 133 could be optional. That is, in one embodiment or mode, the system may be reset as described upon following playback as shown in step 133. In another mode or embodiment, the unlocked condition for unrated information that is 5 established by the override operation may be maintained following completion of playback of the unrated disc, title, program or portion of the information for which override was activated. Controlling the mode which establishes whether step 133 occurs or not can be accomplished by setting the desired mode during setup, e.g., using a remote control to select desired features from an on-screen display showing 10 a menu of modes and options.

Fig. 11 shows, in flowchart form, another embodiment of a method for controlling a system in accordance with principles of the invention. Steps in Fig. 11 which have the same reference number as in Fig. 10 operate in a similar manner to the corresponding step in Fig. 10 as described above and will not be described again 15 here. The arrangement depicted in Fig. 11 provides for selectively enabling the mode of operation in which user override of an unrated-information lock occurs. Specifically, Fig. 11 includes step 135 following step 123 which tests to determine if the unrated-lock-override mode is enabled. If so (a "YES" result at step 135), step 135 is followed by step 125 and operation to override the unrated lock control 20 condition progresses as described with respect to Fig. 10. If unrated lock override is disabled (a "NO" result at step 135), then step 135 is followed by step 134 which exits the routine without providing the user an opportunity to override the unrated information lock. Override could then occur prior to activation of the playback mode by navigating the usual setup menus as described above if a user desires.

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Enabling/disabling of the unrated information override mode may occur by selecting the desired mode on a setup option display created by the system's on-screen display processor during a setup mode of operation. The setup mode of operation, which enables controlling various features such as video processing 30 characteristics, sound characteristics, closed captioning, etc., in addition to override on-the-fly mode enable/disable, may be activated, for example, by pushing a control button on a remote control. Desired features/modes/settings are selected from the displayed setup menu by using buttons on the remote control.

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It will be apparent to those skilled in the art that although the present invention has been described in terms of an exemplary embodiment, modifications and changes may be made to the disclosed embodiment without departing from the essence of the invention.

5 It is herein recognized that the unrated disc lockout feature may be implemented using any one of a number of conventionally known methods, or combination of methods, for controlling the various elements of disc player 24 described above, for example by using embedded software in a microcontroller. Also, the present unrated disc lockout feature may be implemented for any signal 10 processing system which can be configured to selectively restrict access in response to the presence of parental control ratings, or other program related information, included with stored audio, video and subpicture data stored, for example, on storage media including video tape, DVD video systems, DVD audio systems, DVD-ROM systems, Laser Disc systems, etc. Therefore, it is to be understood that the present 15 invention is intended to cover all modifications as would fall within the true scope and spirit of the present invention.

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Claims

1. A method for controlling a system for processing information stored on a storage medium comprising the steps of:

5 (A) determining whether information stored on the storage medium lacks rating information identifying a rating for a program stored on the storage medium;

(B) providing to a user an opportunity to select whether to override a system lock disabling playback of unrated information stored on the storage medium responsive to determining that the stored information lacks rating information; and

10 (C) enabling playback of the program responsive to user override of the system lock.

2. The method of claim 1 wherein step (C) is followed by the step of disabling playback of unrated information stored on the storage medium upon completion of play back of the program.

3. The method of claim 2 wherein step (A) is preceded by the step of determining whether a mode of operation enabling user override of the system lock is enabled.

20 4. The method of claim 3 wherein step (C) is preceded by the step of prompting a user to enter a password needed to enable overriding the system lock.

5. The method of claim 4 wherein the system comprises a DVD player and the storage medium comprises a DVD disc.

6. A method of controlling a system for processing information on a digital video disk comprising the steps of:

(A) determining whether the digital video disk includes unrated program information;

5 (B) prompting a user during the play mode of operation to select whether to override a control condition of the system to enable playback of the unrated program information; and

(C) enabling playback of the unrated program information in response to the user selecting to override the control condition of the system.

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7. The method of claim 6 wherein step (C) is followed by the step of returning the system to the control condition disabling playback of unrated program information subsequent to completion of playback of the unrated program information.

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8. The method of claim 7 wherein step (A) is preceded by the step of determining whether user override in response to unrated program information is enabled.

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9. The method of claim 8 wherein step (C) is preceded by the step of prompting a user to enter a password needed to enable override.

10. Apparatus for processing information stored on a storage medium comprising:

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means for accessing information stored on the storage medium; and control means for processing the information accessed from the storage medium for determining whether a portion of the program being played includes unrated program information, and for providing to a user in response to detection of unrated program information an opportunity to override a control condition of the apparatus preventing playback of the unrated program information.

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11. The apparatus of claim 10 wherein the control means enables playback of the unrated program information in response to user override of the control condition and wherein the control means returns the apparatus to the control

condition preventing playback of other unrated program information upon completion of playback of the unrated program information.

12. The apparatus of claim 11 wherein the control means is responsive to  
5 user entry of a password for override of the control condition to enable playback of  
unrated program information.

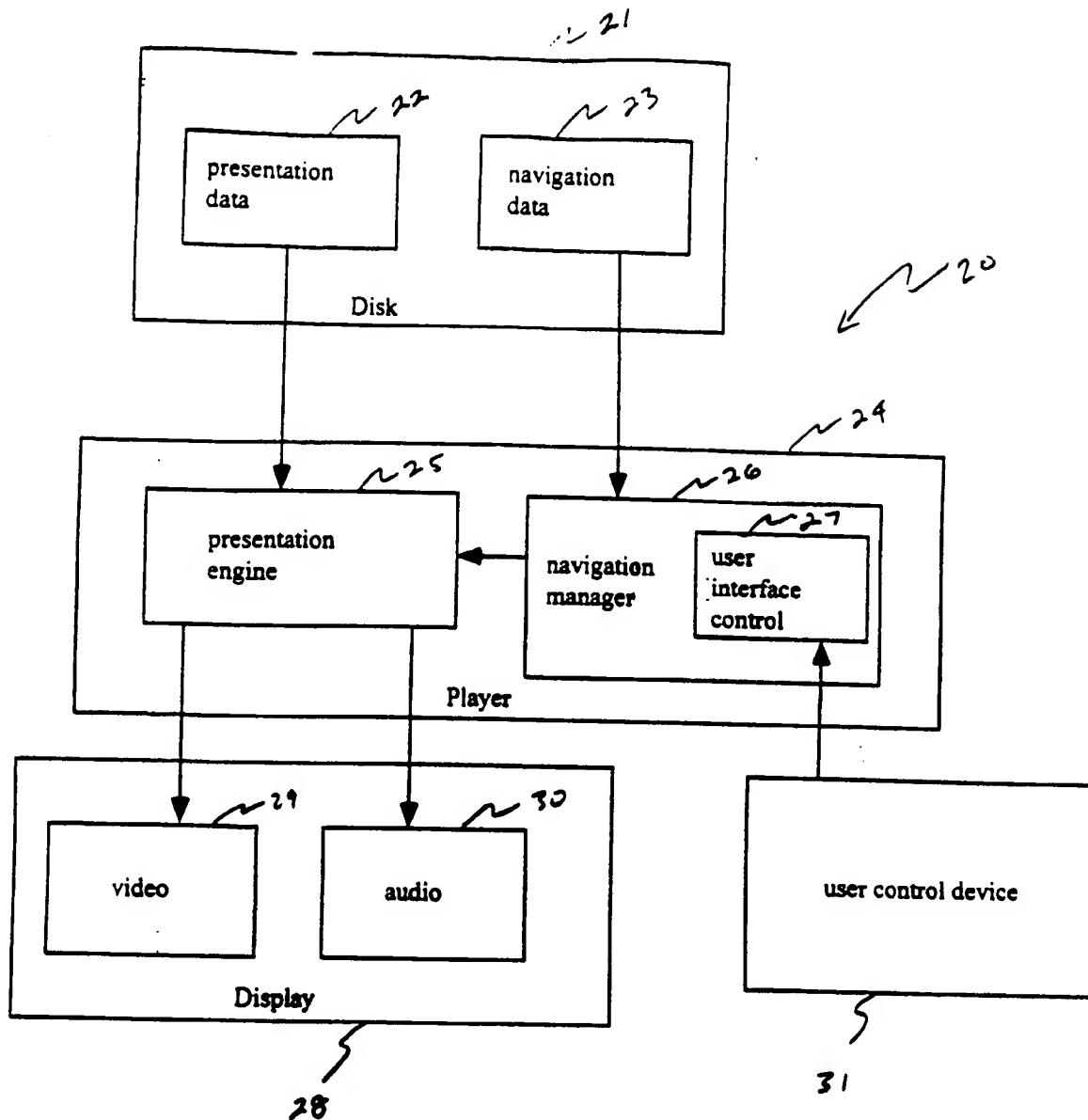


Fig. 1

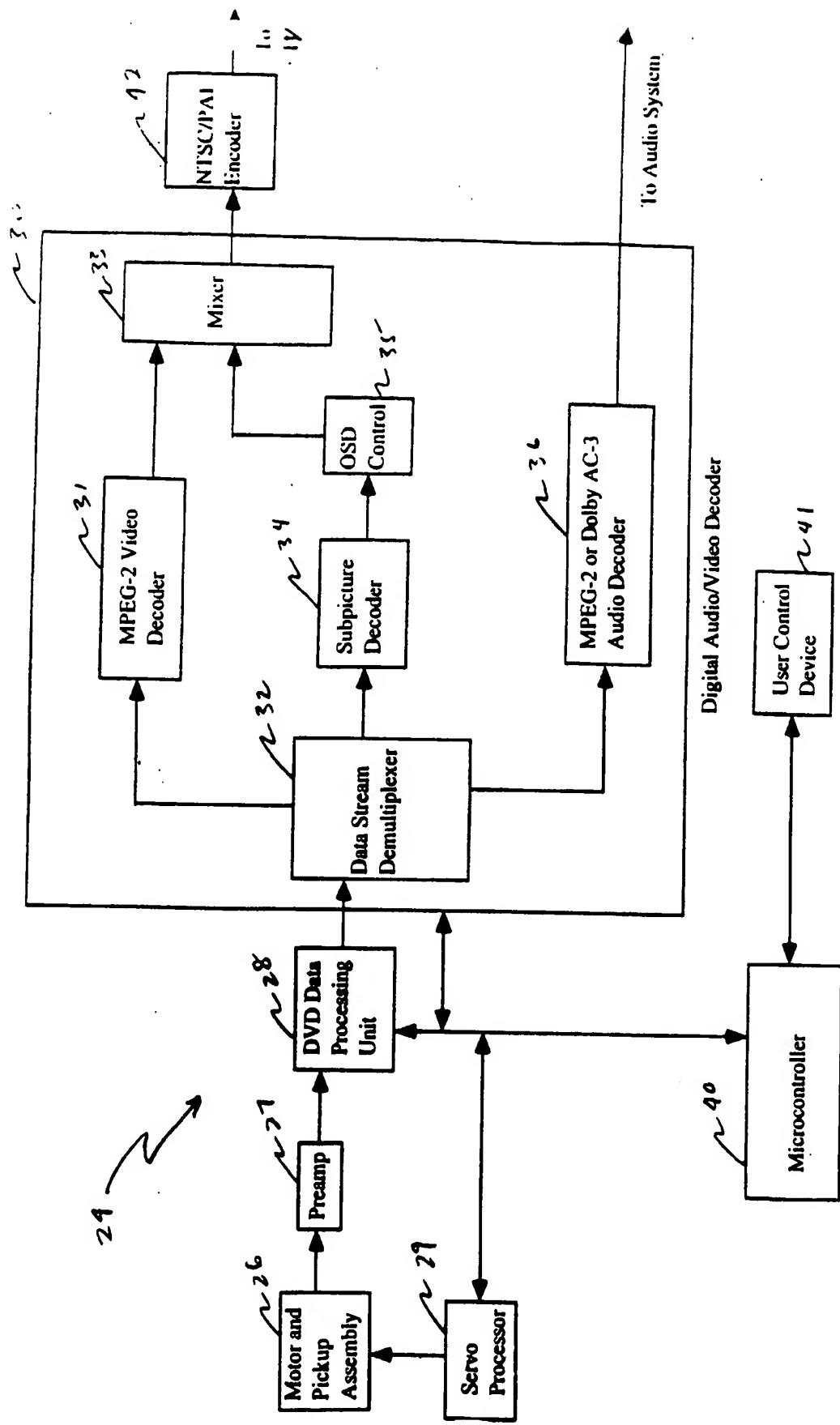


Fig. 2

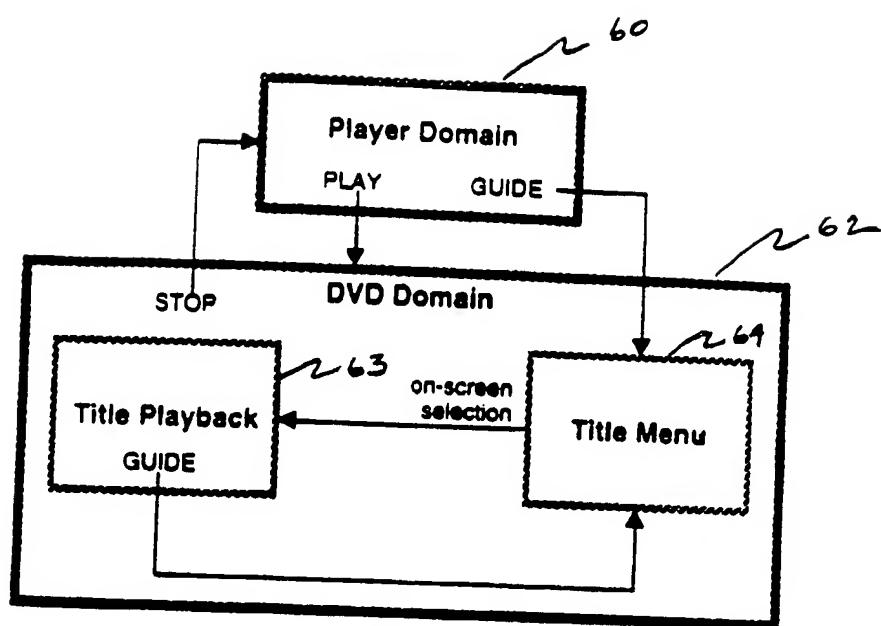


Fig. 3

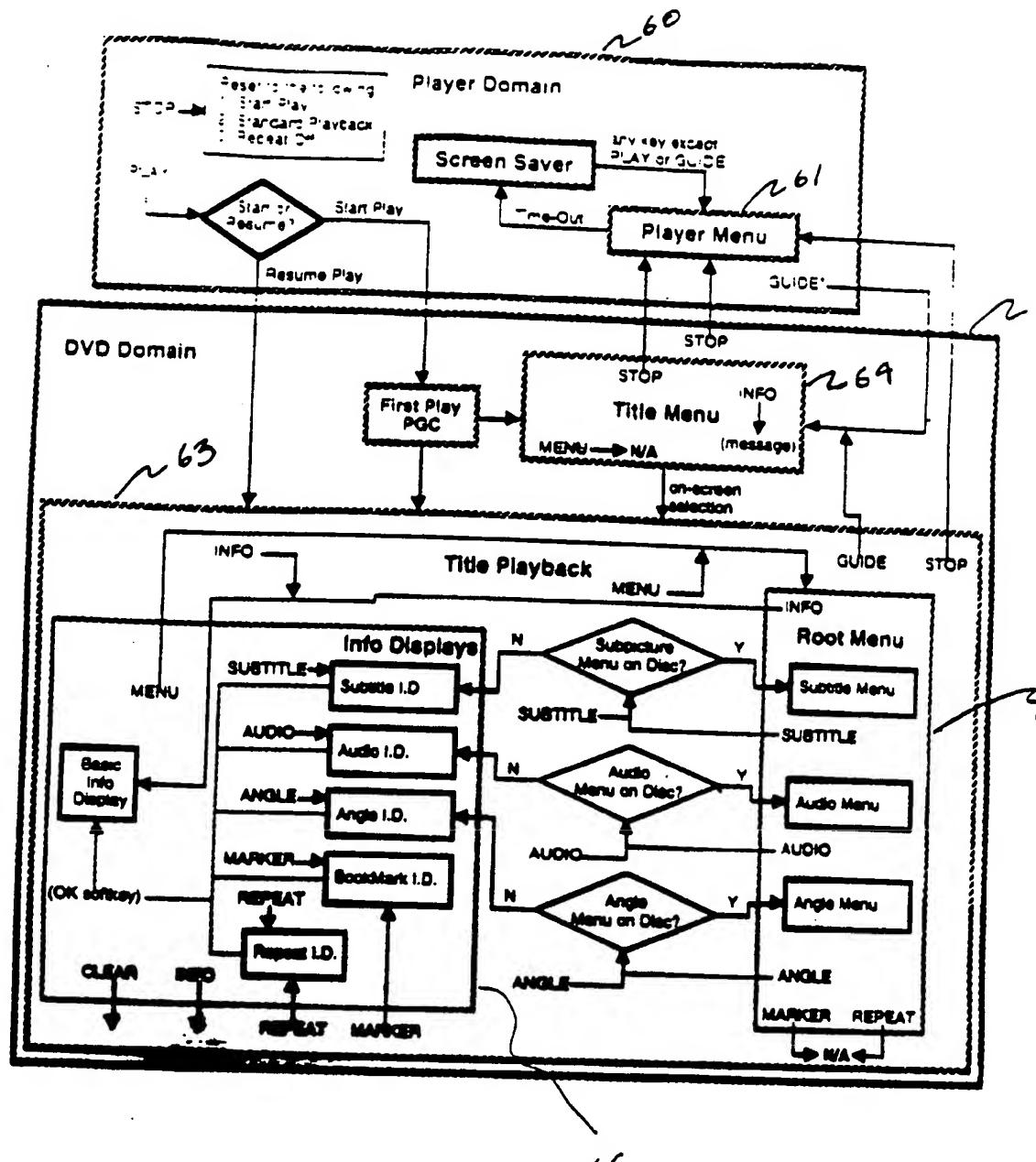


Fig. 4

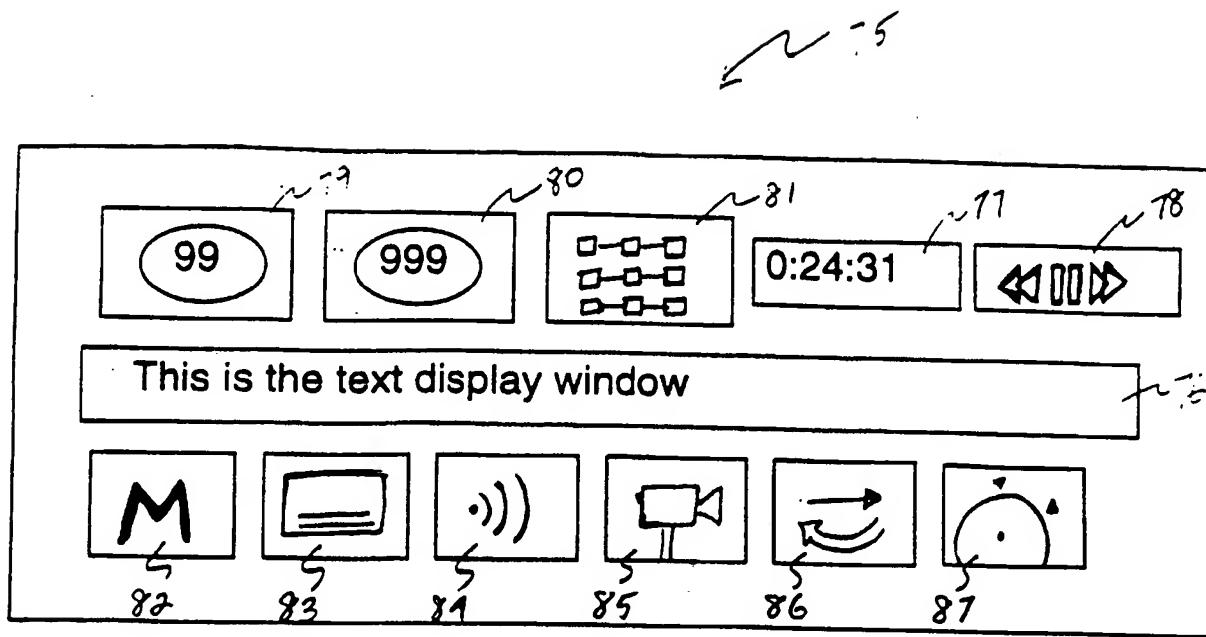


Fig. 5

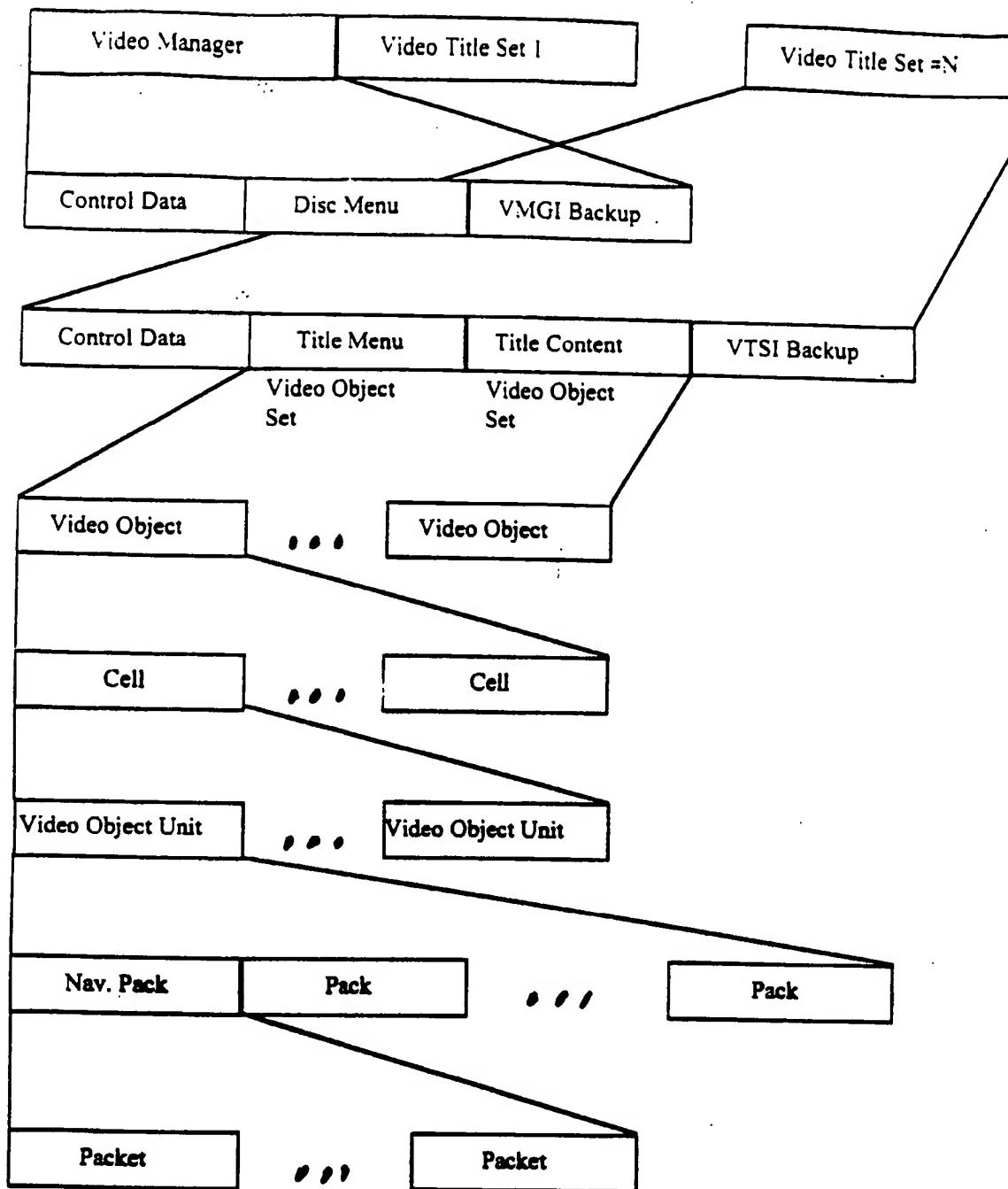


Fig. 6

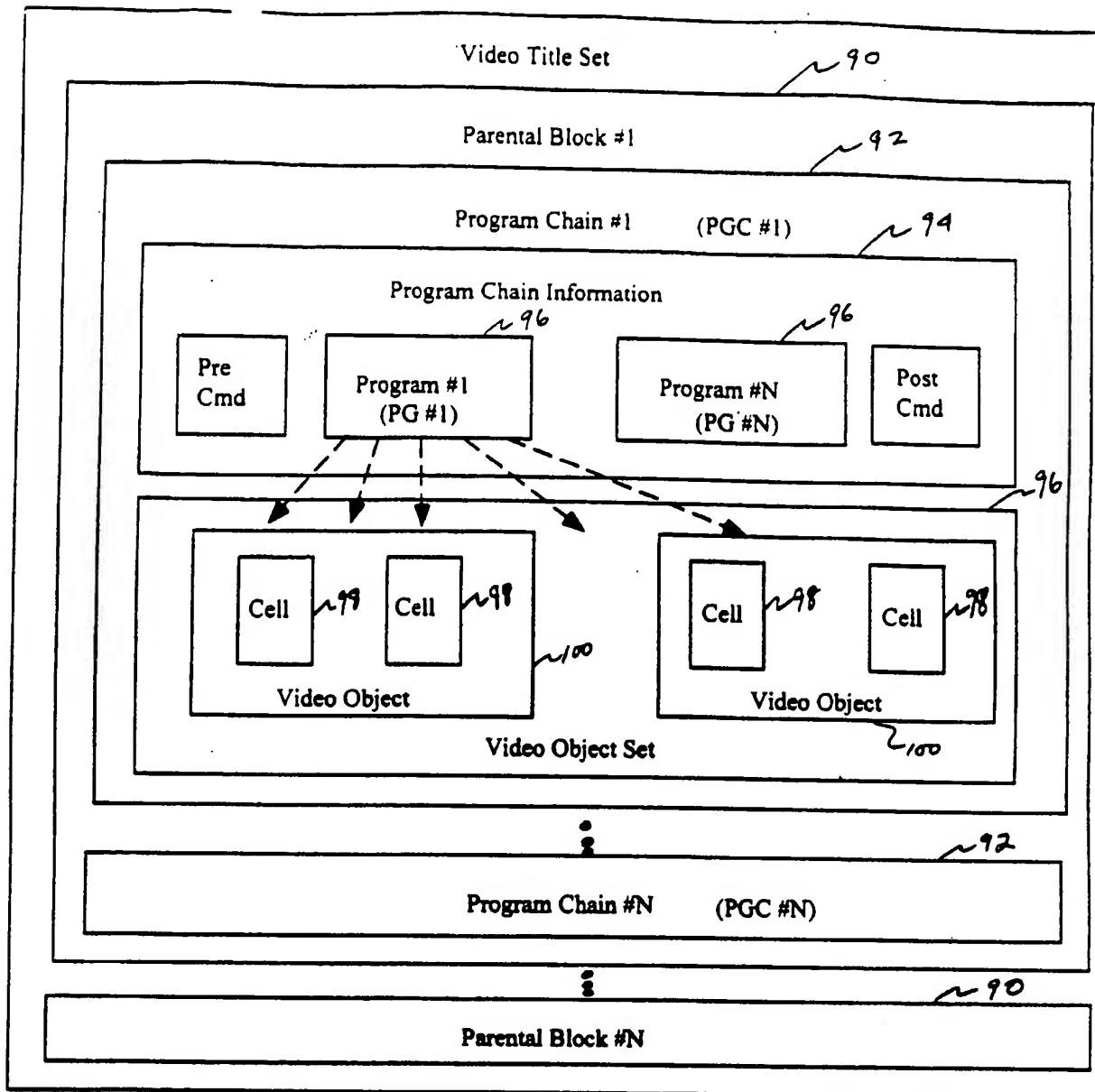
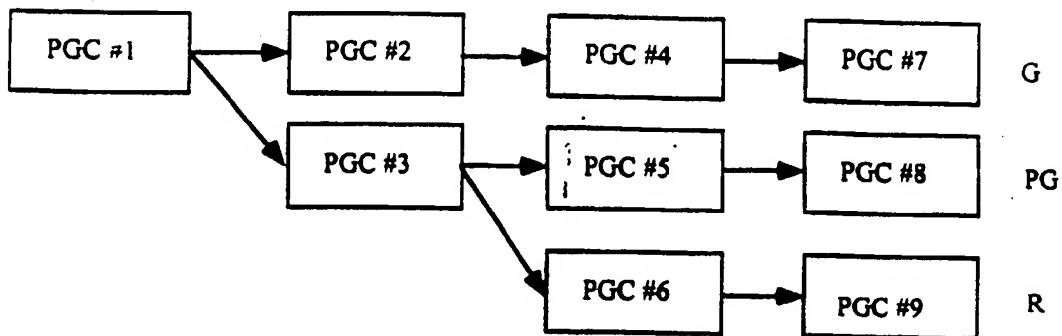


Fig. 7

PGC #1

Single PGC

(a)



Multiple PGCs

(b)

Fig. 8

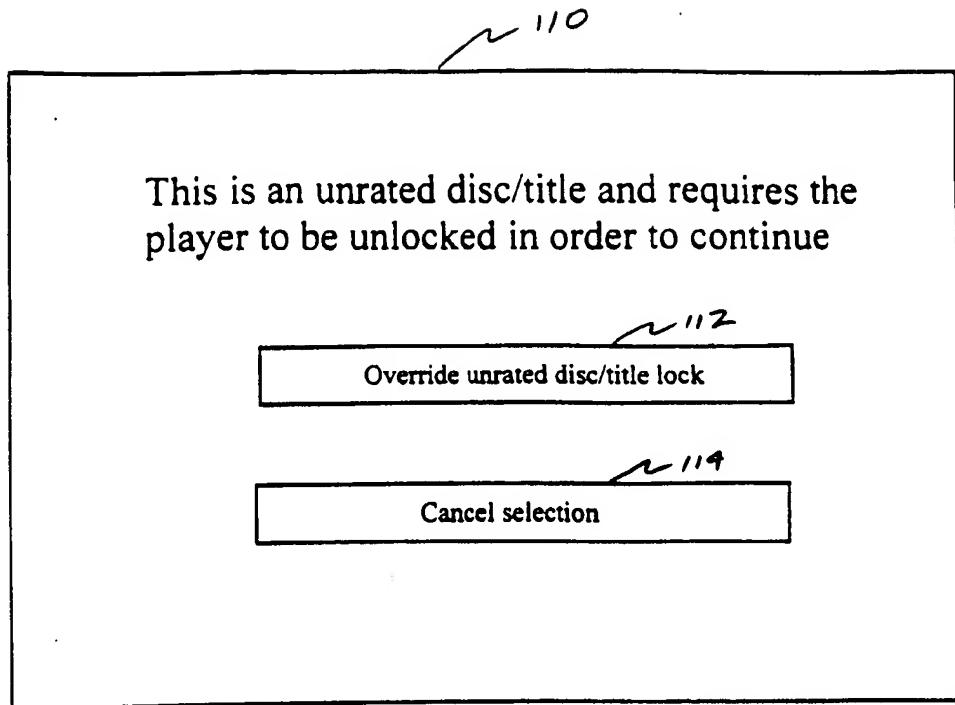


Fig. 9

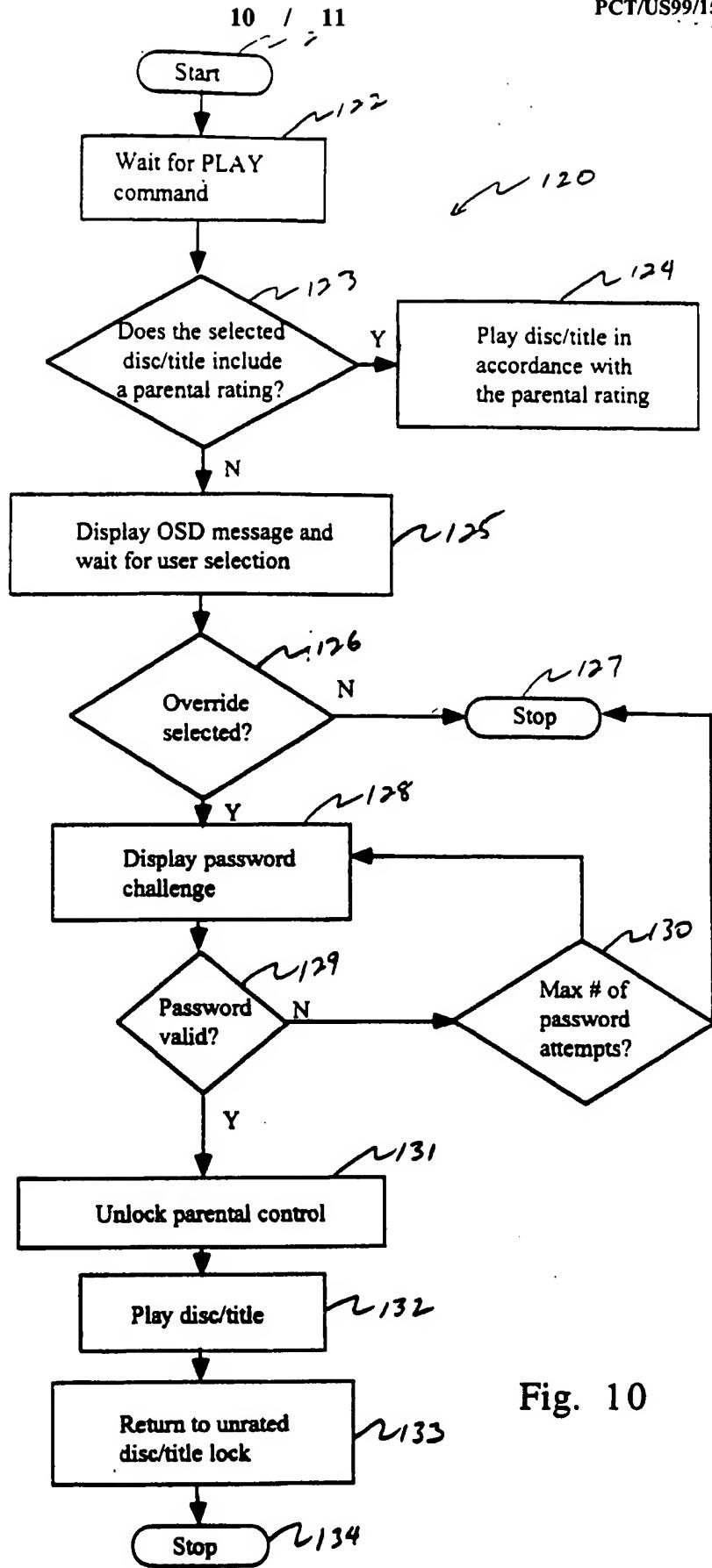


Fig. 10

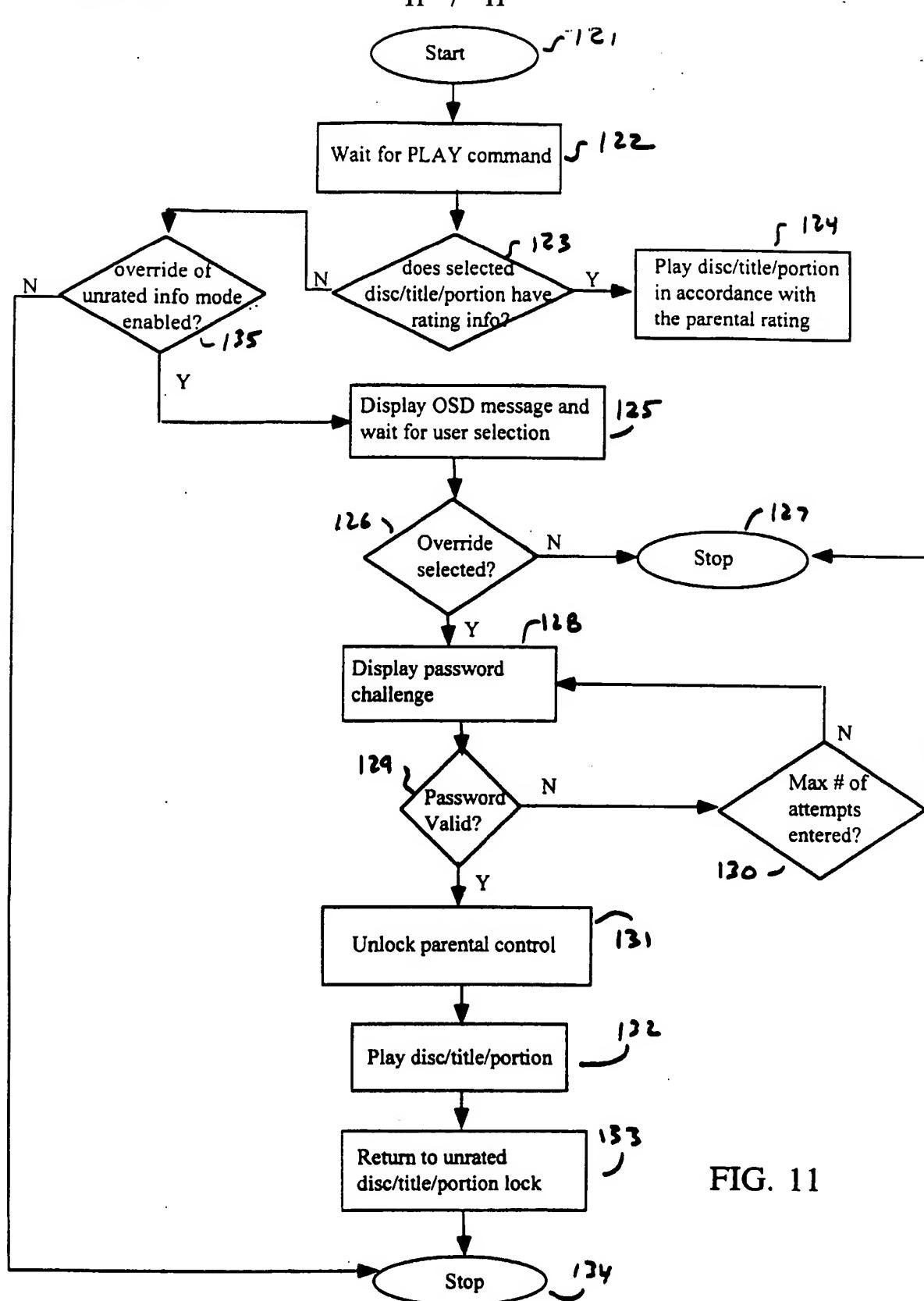


FIG. 11